**The respiratory system**

The respiratory system involves a series of organs that are responsible for breathing in oxygen and breathing out carbon dioxide. The organs in the respiratory system work to provide oxygen to body tissues, remove carbon dioxide as a waste product and help maintain acid-base balance. The structure of the respiratory system consists of two parts: the upper respiratory tract and lower respiratory tract. The upper respiratory tract includes the nose, mouth and the trachea, while the lower respiratory tract includes the trachea, bronchi, bronchiole and the lungs (Altman, and Dittmer 1971). The lower respiratory tract have organs being located in the chest cavity. They are protected by the sternum, ribcage and the muscles between the ribs and the diaphragm. The following parts of the respiratory system are described in detail: The trachea is the tube connecting the throat to the bronchi. The bronchi is the two branching tubes from the trachea. One leads to the left lung, and the other leads to the right lung. Inside the lung, the bronchi divides into smaller bronchi. The broncheoli is a smaller branch of the bronchi, which leads to the pulmonary alveolus. Pulmonary alveoli are the small air sacs that is delineated by a single-layer membrane having blood capillaries. The exchange of gases occurs in the membrane of the pulmonary alveolus, which contains air. Oxygen is absorbed from the air into the blood capillaries and the heart pumps it throughout the tissues in the body. Carbon dioxide is also transmitted from the blood capillaries into the alveoli and then expelled from the bronchi and the upper respiratory tract. The exchange of gases occurs in the inner surface of the lungs, because of the structure of the air sacs of the alveoli. Lastly, the lungs is the pair of organs involved in breathing.

Breathing is characterized by two stages-inhalation and exhalation. Inhalation involves taking in air through expansion of the chest volume, while exhalation involves taking out air from the lungs through contraction of chest volume. Both processes involves muscles: rib muscles and diaphragm muscle (Weibel, 1984). The two muscles move constantly by contacting and relaxing, which causes the chest cavity to increase and decrease. The diaphragm muscles contract during inhalation, hence causing the diaphragm to flatten and the chest cavity becomes enlarged. The rib muscles also contracts and causes the rib to rise, hence increasing the chest volume. During inhalation, the chest cavity expands and reduces air pressure, which causes air to be sucked into the lungs. Air moves from the high pressure outside the lungs to the low pressure inside the lungs. During exhalation, the muscles do not contract but they are relaxed. The diaphragm curves and forms a dome shape, while the ribs descend, which decreases the volume of the chest (Taylor, and Weibel, pp. 6-7). Contraction of the chest cavity increases the air pressure and causes air in the lungs to be expelled through the upper respiratory tract. During exhalation, air moves from high pressure in the lungs to the low pressure in the upper respiratory tract. Both inhalation and exhalation are not voluntary and their control requires an effort.

The respiratory system facilitates breathing, also known as pulmonary ventilation. Air enters the body through the nasal and oral cavities, pharynx, larynx and trachea into the lungs. When air is exhaled, it flows out through the same pathway. Inside the lungs, oxygen is exchanged for carbon dioxide through a process known as external respiration. It occurs through the small sacs called alveoli. Oxygen breathed in diffuses from the alveoli into pulmonary capillaries and binds the hemoglobin molecules in the red blood cells before being pumped through the blood vessels. Carbon dioxide from deoxygenated blood diffuses from capillaries into the alveoli and is expelled through exhalation. Internal respiration exchanges the gases between the bloodstream and body tissues. The bloodstream delivers oxygen to cells and removes carbon dioxide. In this process, the red blood cells carry oxygen absorbed from the lungs around the body through the vasculature. They release the oxygen when oxygenated blood reaches the smaller capillaries. The oxygen diffuses into red blood cells and plasma. Carbon dioxide is carried back to the lungs through the deoxygenated blood.

The conditions necessary for effective gaseous exchange includes the following:

* Temperature: warmer ones increases the diffusion rate between the blood and alveoli.
* Ventilation: must be constant to maintain a concentration gradient to stop equilibrium.
* Thin permeable cell walls to enable faster gaseous exchange.
* Large surface area to volume ratio, in that the more the number of alveoli, the more the rate of gaseous exchange.
* Concentration difference of the gases across all sides.

**Blood**

Plasma is the largest component of blood and makes up 55% of total composition. It is a clear liquid and carries the platelets, red blood cells and white blood cells. Plasma is composed of 91.5% water, and acts as solvent for important proteins, nutrients, electrolytes and other essential substances in the body.

It transports nutrients to the cells of the organs in the body, transport waste products from cellular metabolism to the kidneys, liver and lungs. It is essential in distribution of heat throughout the body and maintains homeostasis. The important constituents of plasma includes amino acids, vitamins, organic acids, vitamins, organic acids, pigments, enzymes and electrolytes. Plasma has 6-8% proteins and one critical group is the coagulation proteins, which is synthesized in the liver. Coagulation inhibitor proteins helps to prevent abnormal coagulation and resolve clots as soon as they form. Serum albumin constitutes around 60% of all the plasma proteins. It is essential in maintaining osmotic pressure in the blood vessels, and an important carrier protein for hormones. The gamma globulins are types of proteins that are secreted by the B-lymphocytes of the immune system. The proteins are part of the body’s supply of protective antibodies produced due to specific viral or bacterial antigens. Cytokines are synthesized by various cells in the body, including the ones in immune system and bone marrow to maintain normal blood cell formation.

The red blood cells are responsible for transporting oxygen to body cells and deliver carbon dioxide to the lungs. It is biconcave, and the shape helps to maneuver through tiny blood vessels to deliver oxygen to organs and tissues. They are also essential in determining the human blood type. The red blood cells have a unique structure: their flexible disc shape increases the surface area-to-volume ratio in delivery of oxygen to organs. They have several amounts of a protein known as hemoglobin, which binds oxygen as oxygen molecules enter blood vessels in the lungs. Its red color is also due to hemoglobin. Compared to other cells, red blood cells lack nucleus, mitochondria or ribosomes so that there is room for hundreds of millions of hemoglobin molecules. The red blood cells are derived from stem cells in red bone marrow and are produced when there is low levels of oxygen in the blood. When the kidneys detect the low oxygen levels, they produce a hormone called erythropoietin that stimulates production of red blood cells. The increase in number of red blood cells in the blood circulation increases the level of oxygen in the blood and tissues.

Oxygen and carbon dioxide are facilitated by the red blood cells and transported through the body via cardiovascular system. Oxygen diffuses across the thin endothelium of alveoli sacs into the blood in surrounding capillaries. Hemoglobin in the red blood cells releases the carbon dioxide extracted from various body tissues and become saturated with oxygen. Carbon dioxide is expelled and the oxygen-rich blood is returned to the heart and pumped to the rest of the body (Saladin, K.S. and Miller, Pp. 125). The oxygenated blood reaches systematic tissues where oxygen diffuses to surrounding cells, and carbon dioxide is produced due to cellular respiration diffuses into the blood. The process is repeated and is referred to as the cardiac cycle (Meste, et al, 2005).

**Circulation of blood**

Blood is transported via the blood vessels, and there are three types of blood vessels: arteries, veins and capillaries. Arteries takes blood away from the heart to the body organs and tissues. The walls of arteries are thick and muscular to hold against the high pressure of blood being pumped away from the heart. Veins collects blood from the capillaries and transport the blood to the heart. The walls of the veins are thin because the blood is at a reduced pressure compared to arteries. Veins contains valves to prevent the backflow of blood. The main artery is the aorta that branches into other arteries, which takes blood to different limbs and organs (Fox, pp. 117-118). Such arteries include the carotid artery, which takes blood to the brain, the brachial artery, which takes blood to the arms, and thoracic artery that takes blood to the thorax.

The heart is an organ that pumps blood through the body. The heart is composed of four chambers namely the two upper chambers or atria and two lower chambers or ventricles.  The atrium and ventricle located on the right make up the “right heart” while those on the left make up the “left heart.” septum which is a muscle wall divides the right and the left heart.

The heart is anchored and protected inside the chest by the pericardium, which is a double –walled sac enclosing the heart.

Blood circulation by the heart is completed through two pathways; the systemic circuit and pulmonary circuit. In the latter, deoxygenated blood moves from the heart’s right ventricle through pulmonary artery to the lungs. This blood later return via pulmonary vein to the left atrium in the form of oxygenated blood.

On the other hand, system circuit involves the movement of the oxygenated blood from the body to the aorta. From here, the blood move into the arteries and capillaries that intern transports it to the body tissues. Deoxygenated blood gets back to the heart through the veins to the venae cavae and enters the right atrium.

**Cardiac Cycle Phases**

Cardiac cycle refers to the path taken by blood as it enters the heart, pumped to the lungs, gets back to the heart, and lastly pumped to the rest of the body. The cycle is characterized by first and second systole, which happen concurrently, and first and second diastole, which also happen concurrently.

**First Diastole**

During this cycle, the atria and ventricles relaxes and the atrioventricular valves open.  This allows the Oxygen –depleted blood to getting back to the heart from the rest of the body to pass via the superior and inferior Vena cavae and flow to the right atrium. The atrioventricular valves (mitral and tricuspid valves) which are now open let the blood pass via atria into the ventricles. Impulses generated by the sinoatrial (SA) node move to the atrioventricular node, which in turn sends, signal that activate the contraction of both atria. Consequently, the right atrium releases its contents to flow into the right ventricle.  Blood is prevented from moving in the reverse into the right atrium by the tricuspid valve, which is located between the right ventricle and right atrium.

**First systole cycle.**

The start of first systole cycle is characterized by right ventricle that is filled with blood from the right atrium. Ventricles get impulses from Purkinje fibers that carry electrical triggers to the ventricles making them to contact. While this is happening, the atrioventricular valves closes and the aortic and pulmonary valves open. Contractions in the ventricular cause’s oxygen –depleted blood in the right ventricle move into the pulmonary artery. Blood is prevented from moving back into right ventricle by the pulmonary valve. Pulmonary artery transports oxygen-depleted blood via the pulmonary route into the lungs. Here, the blood is oxygenated and made to flow back into the left atrium via pulmonary vein.

**Second diastole cycle.**

During the second diastole cycle, semilunar valves close while atrioventricular valves open to allow oxygenated blood enter the atrium via the pulmonary veins (this happens at the same time as blood fills the right atrium from vena cavae). SA node contracts once more to trigger contraction in both atria. This contraction makes the left atrium to release its content to the left ventricle. (This happens even as the right ventricle receives blood from the right atrium).  Oxygenated blood is prevented from getting back into the left atrium by mitral valve located between left ventricle and left atrium.

**Second systole cycle.**

This cycle starts with the closing of atrioventricular valves and opening of semilunar valves. Impulses are sent to the ventricles causing them to contact. Oxygenated blood filling the left ventricle is pushed to the aorta stopped by aortic valve from getting back to the left ventricle (during the same period oxygen-depleted blood is pushed into the pulmonary artery from the right ventricle).   Aorta supplies oxygenated blood to rest of the body via systemic circulation. Once the blood has circulated throughout the body and is now depleted of its oxygen, it returns to the heart through venae cavae.

**Calculation of cardiac Output**

Cardiac output calculation is important because it measures of the health and function of the cardiovascular system. Cardiac output is calculated using two variable namely stroke volume and heart rate

Cardiac Output = Stroke Volume \* Heart Rate, which is written CO = SV \* HR

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